Stoichiometry: Chemical Equations and the Mole

May 10, 2011

Stochiometry is the relationship between amounts of reactants and products involved in chemical reactions. Stochiometry is based on knowing the mole ratio between two compounds involved in the reaction. To determine the mole ratio you must begin with a balanced chemical equation.

Consider the reaction between hydrogen gas and nitrogen gas to make ammonia.

The chemical reaction is:

$$3H_2 + N_2 \longrightarrow 2NH_3$$

The mole ratio is determined by the coefficients of the balanced chemical equation. So for this reaction the mole ratio is $3\text{ mol } H_2 : 1\text{ mol } N_2 : 2\text{ mol } NH_3$.

We use the mole ratio in stoichiometric calculations as a conversion factor between moles of one compound and another.

Example #1: Calculate the mass of water that forms from the combustion of 8.00 g of hydrogen gas.

Solution:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

$8.00\ g$ of H_2; $M_{H_2} = 2.02\ g/mol$

$?\ g$ of H_2O; $M_{H_2O} = 18.02\ g/mol$

$n_{H_2} \longrightarrow n_{H_2O}$

$\frac{2\ mol\ H_2}{2\ mol\ H_2O}$, $\frac{2\ mol\ H_2O}{2\ mol\ H_2}$ ← mol ratios

$$n_{H_2} = 8.00\ g \times \frac{1\ mol}{2.02\ g} = 3.96\ mol\ H_2$$

$$n_{H_2O} = 3.96\ \cancel{mol\ H_2} \times \frac{2\ mol\ H_2O}{2\ \cancel{mol\ H_2}} = 3.96\ mol\ H_2O$$

$$m_{H_2O} = 3.96\ \cancel{mol}\ H_2O \times \frac{18.02\ g}{1\ \cancel{mol}} = 71.3\ g.$$

∴ 71.3 g of water is produced.

Example #2: What mass of oxygen is required for the complete combustion of 10.0 g of propane.

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

10.0 g → $n_{C_3H_8}$ ⟶ n_{O_2} → ? g.

$M_{C_3H_8} = 44.11$ g/mol

$M_{O_2} = 32.00$ g/mol.

$\frac{1 \text{ mol } C_3H_8}{5 \text{ mol } O_2}$, $\frac{5 \text{ mol } O_2}{1 \text{ mol } C_3H_8}$

$$n_{C_3H_8} = 10.0 \text{ g} \times \frac{1 \text{ mol}}{44.11 \text{ g}} = 0.2267 \text{ mol } C_3H_8$$

$$n_{O_2} = 0.2267 \text{ mol } C_3H_8 \times \frac{5 \text{ mol } O_2}{1 \text{ mol } C_3H_8} = 1.133 \text{ mol } O_2$$

$m_{O_2} = 1.133 \text{ mol } O_2 \times \frac{32.00 \text{ g}}{1 \text{ mol}} = 36.3 \text{ g } O_2.$

∴ the combustion needs 36.3 g of oxygen gas.

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